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Optimal design of ground source heat pump system integrated with phase change cooling storage tank in an office building

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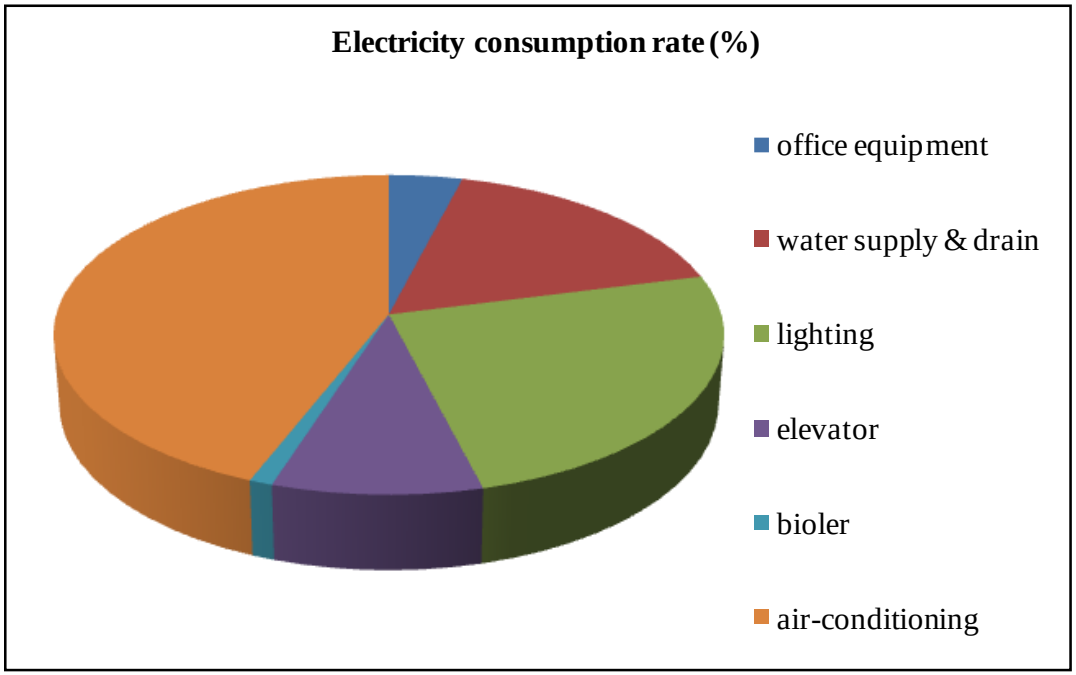
Contents

Background

- The HVAC system accounts for about 44% for the electricity consumption in hotel in China.



Background

- Common air-conditioning system:

➢ Splitting air-conditioner for cooling and coal fired boiler for heating.

- Problems:

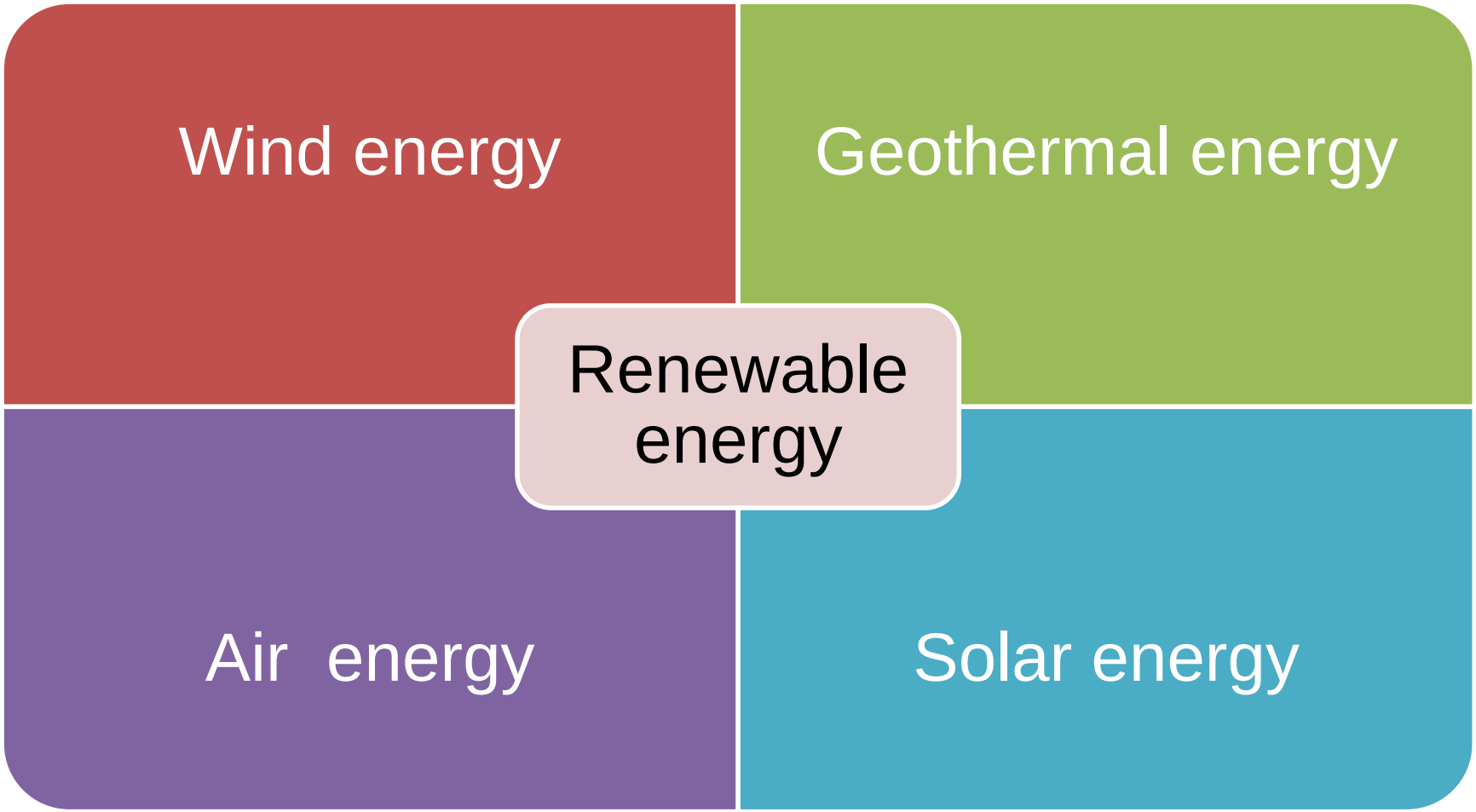
a) Energy c

b) This system

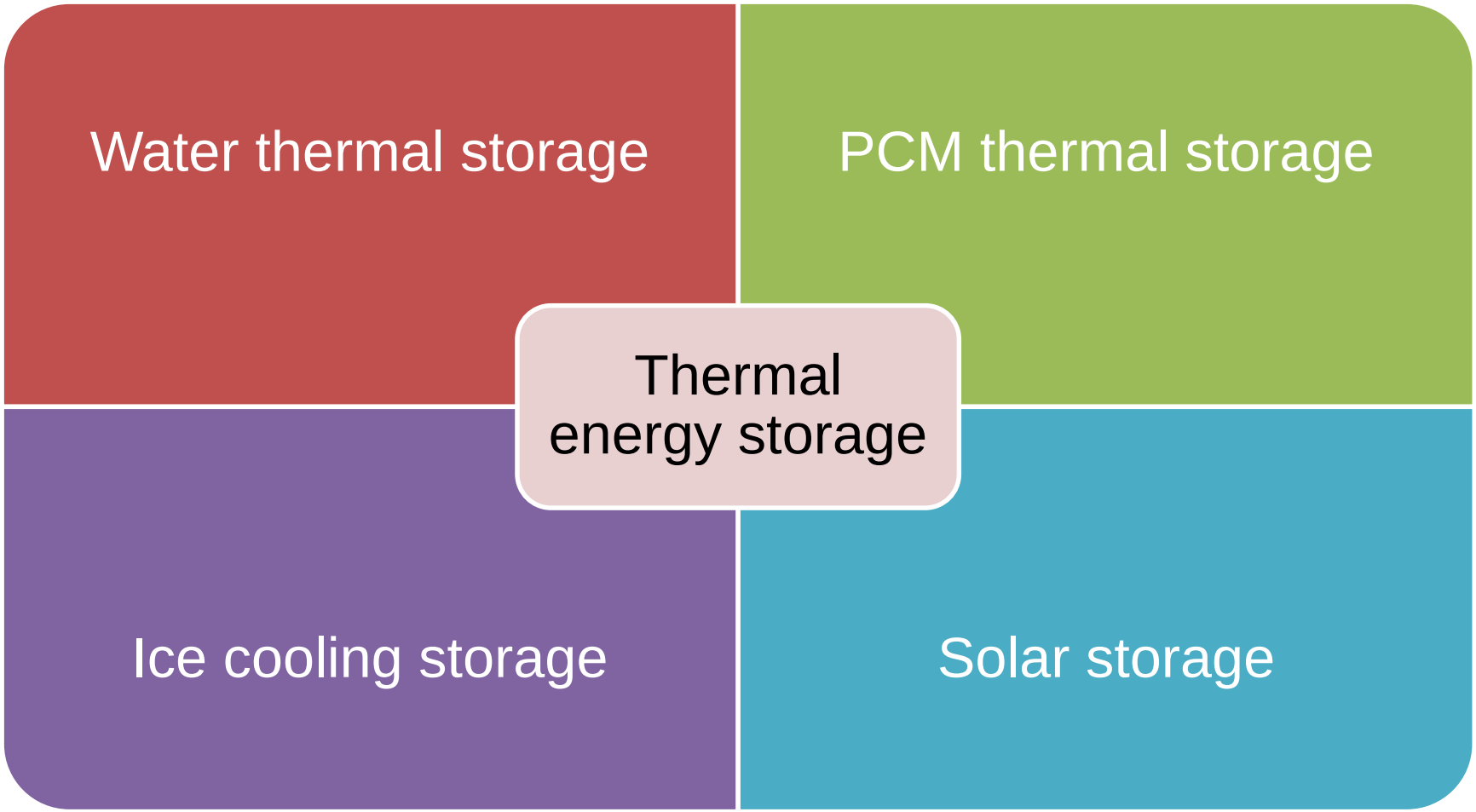
New energy saving technology

al friendly

Background


Wind energy
Geothermal energy
Renewable energy
Air energy
Solar energy

Background


Water thermal storage
PCM thermal storage
Thermal energy storage
Ice cooling storage
Solar storage

Background

- How to decrease the air-conditioner energy consumption?

✓Renewable energy and thermal energy storage technology:

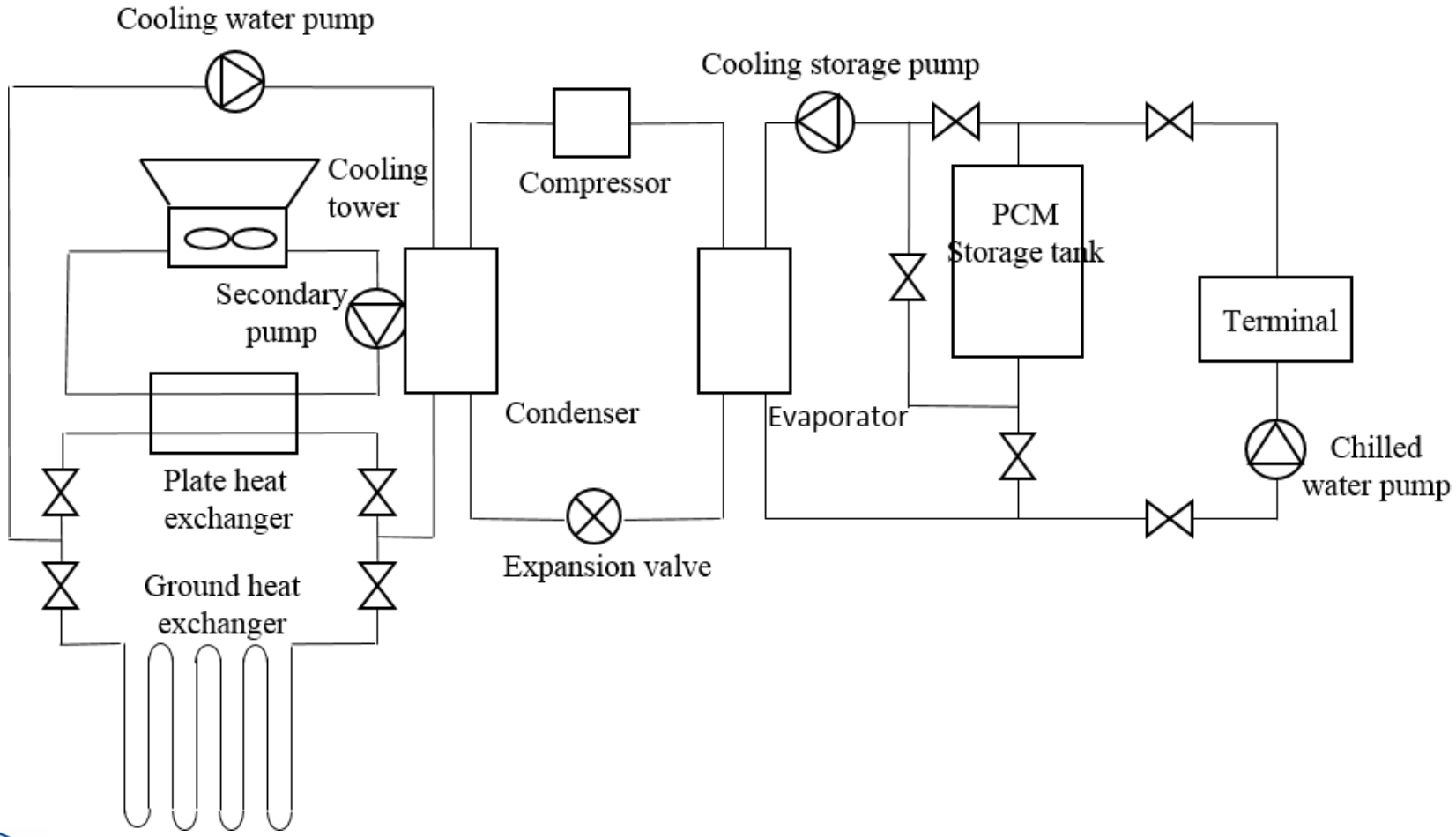
a)Ground source heat pump system

b)PCM thermal storage

Introduction

- This hotel is located in **Wuhan** (latitude 30.52° N, longitude 114.32° E) and the area is 2200 m^2.
- This office has a total air-conditioning area of 5175m^2.
- The cooling load and heating load of this hotel is 1045kW, 432kW, respectively, estimated by eQuest software.

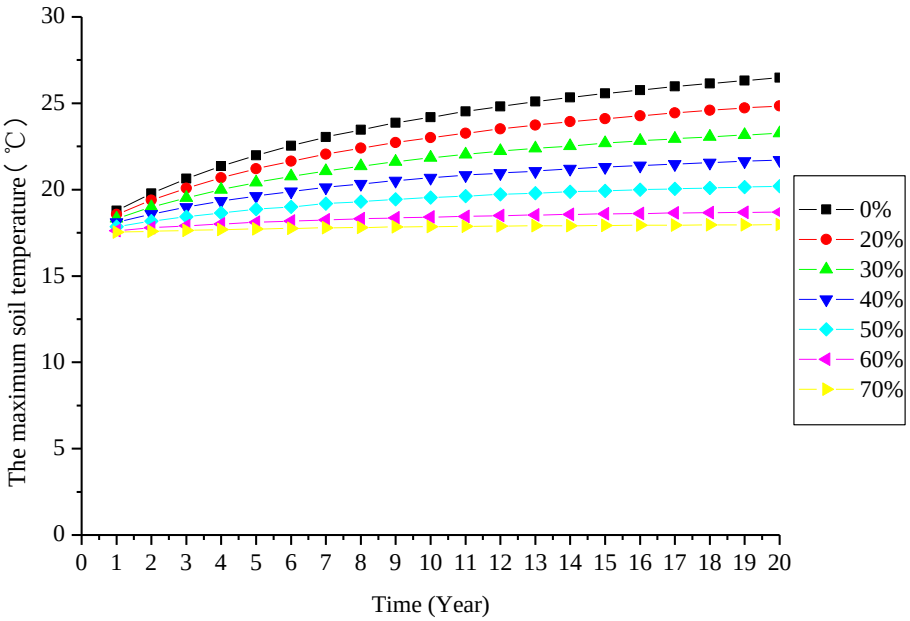
System design



System design

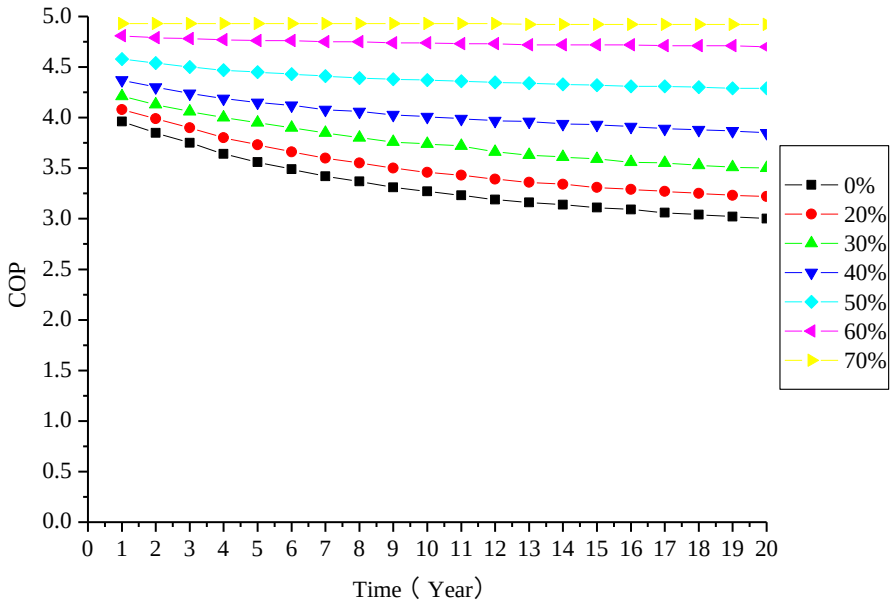
- Operation modes:
  - Summer: Charging cooling in cooling storage tank during night, and opens cooling towers. Discharging cooling during the day, and closes cooling towers, so cooling is provide by ground source heat pump and cooling storage tank.
  - Winter: Heating load is supplied by ground source heat pump systems totally.
  - Remaining season: System stops operating from Mar. 1st to May 31st and Oct. 1st to Nov. 30th.
- Operation modes are switched by the control on different valves.

Analysis of results



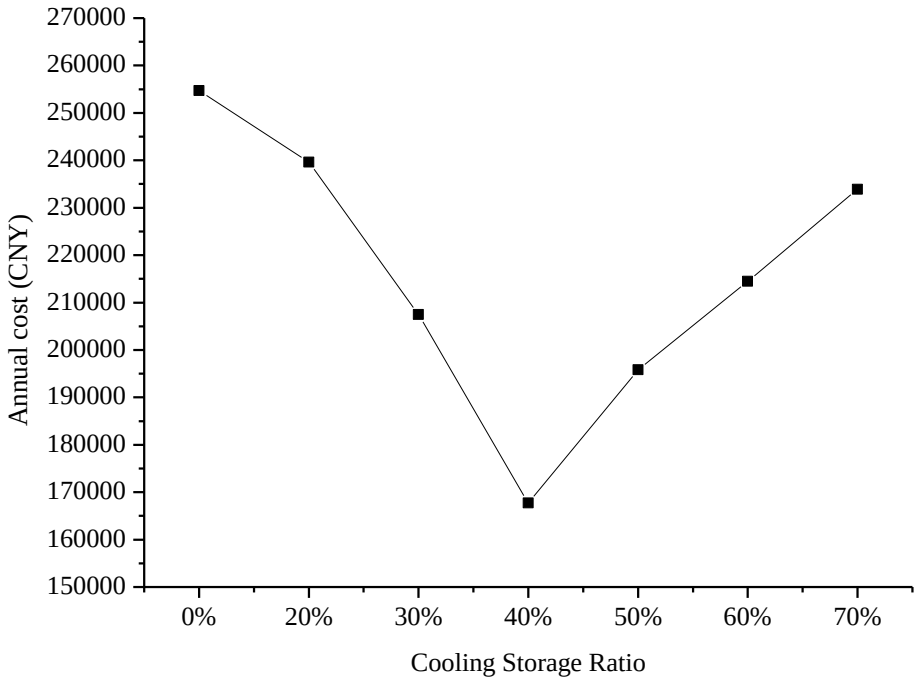
- With the increase of cool storage rate, maximum average soil temperature decreases with the increase of cooling storage ratio.
- The initial soil temperature increases from 17.3℃ to 26.48℃、24.85℃、23.26℃、21.71℃、20.19℃、18.7℃ and 17.97℃ under ration 0%,20%, 30%, 40%, 50%, 60% and 70%, respectively.
- Storage ratio increased by 0.1 per, The annual average temperature of soil Increased increases 0.46℃、0.38℃、0.3℃、0.22℃、0.14℃、0.07℃ and0.03℃ under ration 0%,20%, 30%, 40%, 50%, 60% and 70%, respectively.

Analysis of results



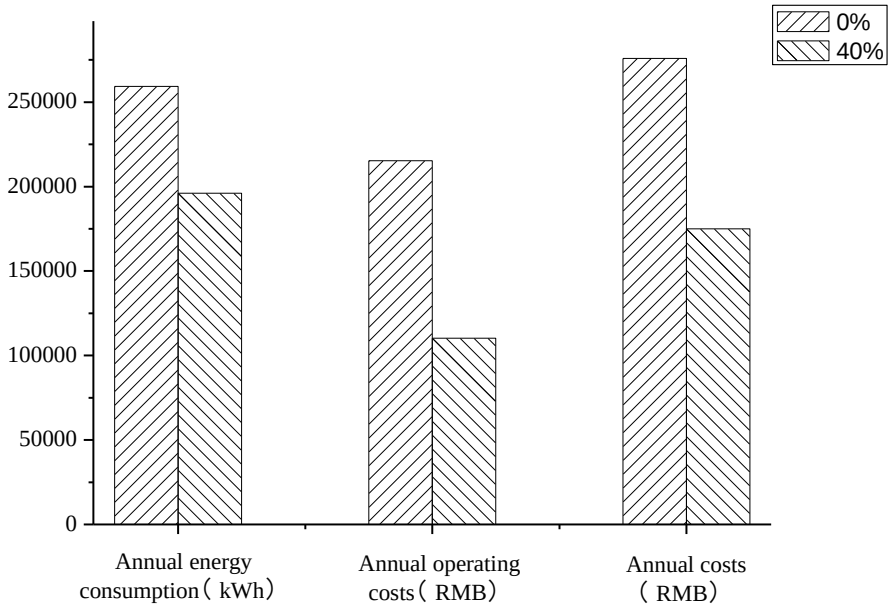
- With the increase of cool storage rate, The COP decreases with the increase of cooling storage ratio.
- The COP decline 0.96、0.86、0.71、0.52、0.29、0.11、0.01 under ration 0%,20%, 30%, 40%, 50%, 60%, 70%.
- After 20 years operation, the COP reduce to 3.5 under ration 0%,20%, 30%，this is not energy-saving. Other cases remained at a high value.

Analysis of results



- The annual energy consumption of the system decreases with the cooling storage ratio and achieves the lowest valuations under cooling storage ratio 40%, and then energy consumption gradually increases.
- The optimal cooling storage ratio is 40% when the annual cost is minimal.

Analysis of results



- The annual energy consumption of the combined system under cooling storage ratio of 40% was reduced by 24.4% compared with that without cooling storage.
- The annual operation cost of the combined system under cooling storage ratio of 40% was reduced by 63.8% compared with that without cooling storage.
- The annual cost of the GSHP combined PCM cooling storage system under cooling storage ratio of 40% was reduced by 34.2% compared with common GSHP hybrid cooling tower system without cooling storage.

Conclusions

1. The partial cooling storage and cooling storage prior mode is used for PCM cooling storage system. The operation mode can make the storage cooling energy release fully and improve the utilization efficiency of cooling storage system. This mode could provide stable and reliable control for the combined system.
2. The maximum soil temperature decreases with the increasing of cooling storage ratio. Soil temperature increases significantly during the previous ten years, and tends to be stable after ten years.

Conclusions

3. During twenty years operation, the energy consumption and operating cost increases firstly and then decreases with the increases of cooling storage ratio. Considering initial investment and operation cost, the optimal cooling storage ratio is 40%.
4. The annual cost of the GSHP combined PCM cooling storage system under cooling storage ratio of 40% is reduced by 34.2% compared with common GSHP hybrid cooling tower system without cooling storage.

Thank you !